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Mapping Fluvial Geomorphic Change: The Clark Fork River at the Former Milltown Dam Site

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Introduction

The Clark Fork River is a dynamic waterway at the headwaters of the Columbia River Watershed. In 2010, the river and its entire watershed were altered with the final removal of Milltown Dam. As the landscape adjusts there will be rapid changes of river channels. Utilizing some simple remote sensing techniques such as vegetation indices, we can better understand and visualize these changes quickly and efficiently. The results reveal the formation of primary, secondary, and tertiary channels. Available imagery allowed mapping of changes between 2010 and 2017.

Figure 2. Map displaying a satellite image of study site in 2011, with the main straight bypass channel still in tact. Data provided by NAIP 2011.

Data & Methods

To map the new channels forming, two images were located in USGS EarthExplorer'. For 2010, an image from Landsat 5's Thematic Mapper (TM) sensor was used. The 2017 image was from Landsat 8's Operational Land Imager (OLI) sensor. Each image is a series of bands from different parts of the spectrum ranging from blue to shortwave infrared. These bands were downloaded as a geotiff and imported into TerrSet. Bands were arranged to produce a false color image for each year by using the green, red, and near-infrared bands (Figures 5 and 6). This enhances the imagery so differences in the secondary channels can be seen more readily due to the different wavelengths. To better visually differentiate and channels, a Normalized Difference Vegetation Index (NDVI) was also produced. The images were treated as matrices and the values for the near infrared band (NIR) and red bands for each image were use in the equation:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}.$$

NDVI is vegetation index that ranges from -1 to 1 (Rouse et al., 1973) and is normally used to quantify vegetation health, but also works well to identify water flowing through a vegetated floodplain.

Acknowledgements

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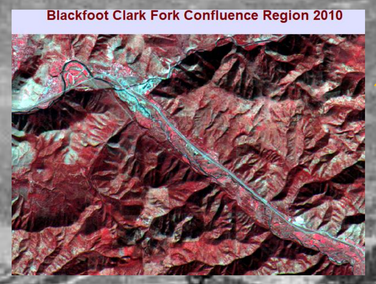


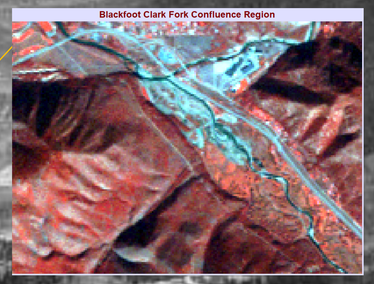
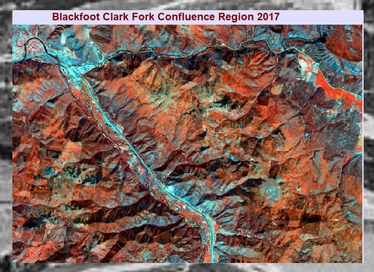


Figure 5: Displays the false color image zoomed in on the study site of former Milltown Reservoir 2010



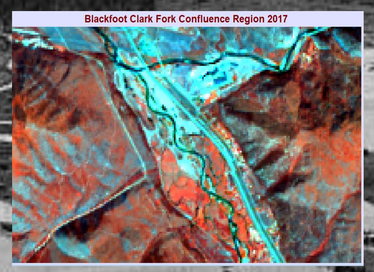


Figure 6: Displays the false color image zoomed in on the study site of former Milltown Reservoir 2017

Results

The false color and NDVI display the channel changes between the 2010 and 2017 false color images (Figures 7 & 8). As indicated by the arrows above, we can see channelization happening both in the anastomosing portion of the floodplain as well as developing meanders/braids running through the exposed sediment in the former reservoir bed. Most importantly, one can see the meandering channel that later replaced the straight bypass channel.

Vegetation is also clearly depicted on the NDVI which can help provide structural constraints and indications of where the channels will form and develop. The vegetated areas are shown ranging from bright yellow to green and darker green. The NDVI values can be interpreted as 0 to 1 being vegetation and -1 to 0 being non-vegetation, showing spatial differences of water versus vegetated floodplain. The distribution of pixel values can be seen in Figure 9 as a histogram, showing that the majority of pixel values were above 0 (no vegetation). Within the vegetated floodplain vegetation indices indicate evidence of channelization (Figure 8).

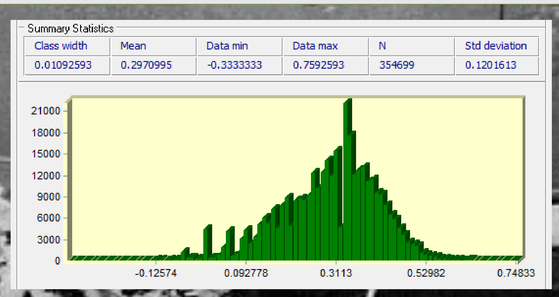


Figure 9: Histogram of pixel value distribution of NDVI in the floodplain, using the NDVI scale ranging from -1 to 1.

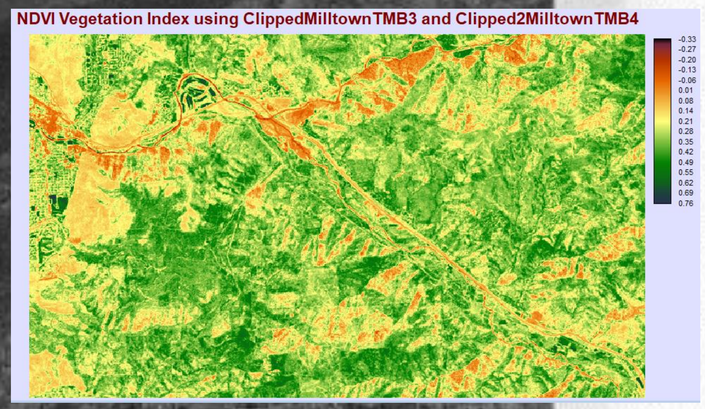


Figure 7: Displays the full extent of the NDVI not zoomed in, data acquired from TM Red & NIR bands.

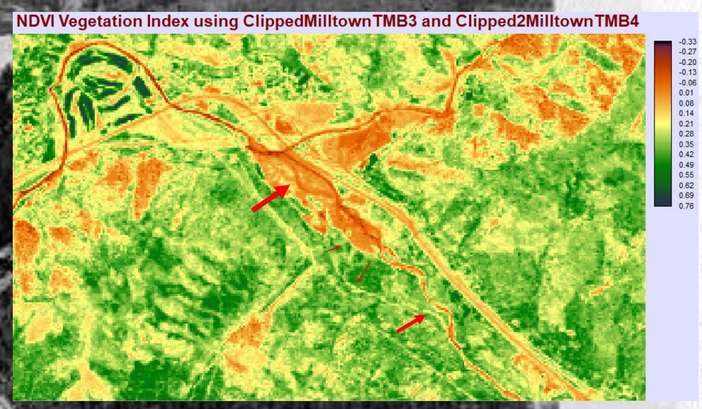


Figure 8: Displays the zoomed in with arrows indicating evidence of the channels present in 2017 that were previously unseen developing in 2010 False Color Image

Conclusions

This workflow allowed visualization of channel changes over time, and that utilizing data from sensors revealed changed not visible to the human eye. While the research at Milltown showed very rapid changes, this workflow can be used on any floodplain or watershed. This workflow was quick, revealed key information, and provides the basis for even more in-depth channel classification to be done remotely or could inform planning for in situ studies.

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